NOAA Cooperative Agreement Program: A Collaborative Ballast Water Treatment Test Bed Platform for the Purpose of Determining the Effectiveness of Injecting Ozone Into Ballast Water to Kill Invasive Aquatic Species

Submitted to

Dorn Carlson – NOAA National Sea Grant Program Coordinator

Applicant: **Nutech O3, Inc.**
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Principal Investigators:

Michael Jennings, Nutech O3, Inc - Administrative

William J. Cooper – UNC Wilmington - Science

Rich Mueller, Northeast Technical Services, Co., Inc. – Technical/Engineering

Associate Investigators

To be identified

Academic Institutions and Private Enterprise Contributors

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Proposed Funding Period: May 1 2004 – May 31, 2005

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Principal Investigator - Administration

<u>NOAA Cooperative Agreement Program:</u>

A Collaborative Ballast Water Treatment Test Bed Platform for the Purpose of Determining the Effectiveness of Injecting Ozone Into Ballast Water to Kill Invasive Aquatic Species

I. Introduction of Organizations and Investigators

Nutech O3, Inc.

Nutech O3 is a second stage water recycling and pollution control technology developer headquarted in Arlington, Virginia. The Company was organized in December 1997. In 1998, Nutech was contacted by British Petroleum and asked if Nutech could adapt its waste water recycling technology for use in killing aquatic nuisance species found in ballast water on its oil tankers. In response, Nutech developed and patented the ballast water treatment process technology that was installed on the British Petroleum Tanker S/T Tonsina in the Summer of 2000. That System used stone diffusers to distribute 2,000 grams of ozone, per hour, into the 12 million gallons of ballast water carried on the Tonsina.

Prior to testing the ozone injection system on board the ship, Nutech retained the LaQue Corrosion Institute, of Wrightsville Beach, North Carolina to conduct a series of test to determine if ozone would corrode a ship's hull if it were injected into its ballast water. Extensive testing conducted by the Institute clearly demonstrated that ozone did not, to any degree, damage the test hull.

Full scale, at sea testing was conducted during 2001/2002 and the Ballast Water Task Force issued their report, in June 2002. The Task Force Report demonstrated that ozone injected into ballast water was a highly effective means of killing those aquatic nuisance species. It also indicated that ozonated water would not pose an environmental threat to the water into which it was discharged

The independent Ballast Water Task Force designed the required testing protocol and conducted the at sea testing of Nutech's equipment. Research scientists from the Smithsonian Institution's Environmental Research Center and the U.S. Fish & Wildlife Service and scientists from the University of North Carolina-Wilmington, the University of Washington, Western Washington University, ENSR, Inc., of Greeley, Colorado and engineers from Northeast Technical Services Co., Inc. of Cleveland, Ohio worked on all aspects of the protocol design and at-sea testing of the equipment.

Northeast Technical Services Co., Inc.

Northeast Technical Services Co., Inc. (NETSCo) was formed in May, 1984. For the past 20 years, it has served the maritime industry as a premier design and engineering firm, serving the Great Lakes and deep sea marine industry. We provide a complete range of services, including naval architecture, marine engineering, and consulting services. Our particular expertise is in assisting vessel owners with design and operational problems to help make their vessels operate more efficiently and cost effectively. We routinely perform work for Clients who are updating equipment, contemplating equipment replacement, or who are experiencing problems which require engineered solutions. Our technical staff has an unsurpassed background not only in engineering, but in shipyard work and actual ship operations. This experience allows us to have firsthand knowledge to put to use for ship owners.

NETSCo has had extensive experience in both the design and operati0on of ballast water treatment systems. We were responsible for the design and system integration of the ozone system installation on the S/T Tonsina; as BP is one of our prime engineering clients; as is Alaska Tanker Company, the vessel's operator. NETSCo provided the complete system design, supervised the installation and testing of the system in a Korean shipyard, and provides operating engineers to maintain and operate the system. We have also been involved as the operator for the Great Lakes ANS Demonstration Project, which has a test barge located in Duluth, Minnesota.

NETSCo employs naval architects, mechanical engineers, structural engineers, electrical engineers, field engineers, CAD designers, and CAD drafters. Mr. Richard A. Mueller, the Company's President and CEO, will be in overall charge of the engineering and technical portions of this project, and serve as Co-Principal Investigator, with Mr. Jennings (Admin) and Dr. Cooper (Science).

University of North Carolina at Wilmington

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a. Professional Preparation

Allegheny College Chemistry
B.S. 1969
Pennsylvania State University -Fuel Science/Organic Geochemistry
M.S.1971
University of Miami Marine and Atmospheric Chemistry
Ph.D. 1987

b. Appointments

Jul. 1997 - present	Professor and Chair, Department of Chemistry, University of North Carolina at Wilmington, Wilmington, NC 28403.
Aug. 1992- Jun. 1997	Associate Professor, Department of Chemistry, Florida International University, Miami, FL. 33199. Tenured in 1995.
Oct. 1996- Jun. 1997	Research Professor, Drinking Water Research Center, Florida International University, Miami, Fl. 33199.
Jan. 1980- Oct. 1996	Associate Research Professor, Director, Drinking Water Research Center, Florida International University, Miami, Fl. 33199.
Jul. 1978- Jan. 1980	Department of the Army Civilian with the U.S. Army Medical Bioengineering R & D Laboratory, Environmental Protection Research Division, Ft. Detrick, Frederick, MD.
Dec. 1974- Jul. 1978	Department of the Army Civilian with the U.S. Army Medical Bioengineering R & D Laboratory, Environmental Protection Research Division, Ft. Detrick, Frederick, MD.

RECENT/RELEVANT PUBLICATIONS

Cooper, W.J., R.G. Zika and M.S. Steinhauer. 1985. Bromide Oxidant Interactions and THM Formation: A Literature Review. J. Am. Water Works Assoc. 77:116-121.

Cooper, W.J., R.G. Zika and M.S. Steinhauer. 1985. The Effect of Bromide in Water Treatment. II. A Literature Review of Ozone and Bromide Interactions and the Formation of Organic Bromide. Ozone Science and Eng. 7:313-325.

Amy, G.L., P.A. Chadik, Z.K. Chowdbury, P.H. King and W.J. Cooper. 1985. Factors Affecting the Incorporation of Bromide into Brominated Trihalomethanes During Chlorination, in Water Chlorination Environmental Impact and Health Effects, Volume 5, Chapter 71, ed. R.L. Jolley et al. Lewis Pub., Inc., Chelsea, MI pp. 907-922.

Cooper, W.J., G.L. Amy, C.A. Moore, R.G. Zika. 1986. Bromoform Formation in Ozonated Groundwater Containing Bromide and Humic Substances. Ozone Science and Engineering. 8:63-76.

Gordon, G., W.J. Cooper, R.G. Rice, G.E. Pacey. 1992. Disinfectant Residual Measurement Methods, Second Edition, AWWA Research Foundation and American Water Works Association, Denver, CO. 889 pp.

Mehran, M.F., N. Golkar, W.J. Cooper and A.K. Vickers. 1996. Headspace Analysis of Some Typical Organic Pollutants in Drinking Water Using Different Detectors: Effects of Columns and Operational Parameters. J. Chrom. Sci. 34: 122-129.

Cooper, W.J., J.K. Moegling, R.J. Kieber and J.J. Kiddle. 2000. A Chemiluminescence Method for the Analysis of H2O2 in Natural Waters. Marine Chemistry 70, 191-200.

OTHER PROFESSIONAL ACTIVITIES

Chair - Symposium "Free Radical chemistry in the Environment," 2005 Chemical Congress of the Pacific Rim, Honolulu, HW, Dec. 15-20.

Consultant - 1995 to Present - International Atomic Energy Agency. The use of electron beam treatment for hazardous waste treatment.

Cooper, W.J.; J.R. Cordell; G.M. Dethloff; P.A. Dinnel; R.W. Gensemer ; R.P. Herwig; M.L. House; J.A. Kopp; R.A. Mueller; J.C. Perrins; G.M. Ruiz; G.M. Sonnevil; W.A. Stubblefield; E.VanderWende. OZONE, SEAWATER and AQUATIC NONINDIGENOUS SPECIES: Testing a Full-Scale Ozone Ballast Water Treatment System on an American Oil Tanker, June 2002, 153 pp.

II. Project Description

Statement of the Problem

The worldwide transfer and introduction of nonindigenous species (NIS) by human activities is having significant and unwanted ecological, economic, and human-health impacts. Although most attention to date has focused on invasions in terrestrial and freshwater habitats, it is evident that NIS invasions have become a potent force of change in coastal marine ecosystems. Roughly 400 marine and estuarine NIS are known to be established in North America alone, and over 200 of these species may have occurred in a single estuary. Some of these species have become numerically or functionally dominant in invaded communities, where they have significant impacts on population, community, and ecosystem-level processes. Although many transfer mechanisms (or vectors) have contributed historically to the invasion of coastal habitats by NIS, shipping has been widely considered to be the major vector responsible for many of the known invasions. Furthermore, the global movement of ballast water now appears to be the single largest transfer mechanism for marine NIS.

User Groups

- IMO in the finalization and ratification of the treaty as it pertains to ballast water discharge and treatment

- Various Federal and State agencies in development of ballast water discharge and treatment guidelines
    - California State Lands Commission
    - Washington State Department of Fish and Wildlife
    - US Fish and Wildlife
    - US Coast Guard
    - Chamber of Shipping of America
    - MARAD
    - EPA
    - NOAA

Current State of Knowledge

The current studies, that have been on-going for three years, have resulted in a much better understanding of ozone process for ballast water treatment. The experiments have been divided into two general areas, chemistry and biology.

The chemical aspects have involved making sure that an understanding of the fate of ozone is better understood in "real-world" application and what, if any, are the effects of it on the chemical properties of the water. It is clear from our studies that the life-time of ozone is insufficient to be responsible for much, if any, of the effects that we have observed. However, the residual oxidant that is formed, bromine, is the chemical that results in the observed biological control that we have observed. The sea water chemistry has not been affected at all during the tests that have been conducted. That is, the variables such as pH, salinity, nutrient concentrations have not been affected.

The biological aspects of the studies have involved examining organisms at various trophic levels from bacteria to larger caged organisms. The details of the first two years of the studies have been summarized in a report entitled "Full-Scale Ozone Ballast Water Treatment for Removal of Marine Invasive Species." This report, dated June 13, 2002, is available on the Smithsonian Environmental Research Centers invasive species web site. In general, bacteria have consistently been reduced to below detection limits or > 99.99% removal; with no re-growth observed after 30 days of storage in the dark. Phytoplankton, dinoflagellates and microfalgellates were reduced to greater than 95 %. However, it is felt that a better indicator for phytoplankton inactivation (kill) would be to determine chlorophyll levels before and after treatment. This will be used on studies that will be conducted this spring and fall on board the S/T Tonsina. Zooplankton control (> 95 % dead) was achieved at the longer reaction times. An area of active investigation is to look at longer process times using lower ozone doses to determine whether this approach would result in better control; i.e. higher "kill" rates but with lower residual bromine levels. This will involve "ride-along" studies where process times of greater than 10 hours are used. The studies with caged organism resulted in mixed results. It is felt that the cages themselves hamper the dissolution of the ozone or transport of the residual oxidant into the cages and therefore the results underestimate its effectiveness. Additional studies are being conducted to better understand the effect of bromine on larger organisms.

To complement this proposed project, our existing NOAA and USF&W funded projects will continue through for one more year; and because the same scientific team will participate in both, a more thorough understanding of the total ozone process will be achieved.

Current Support

- Sea Grant Aquatic Nuisance Species Research Program: Redesign and Testing of Water Intake Systems for the Control of Aquatic Nuisance Species using Ozone - The proposed project is the natural progression of the above mentioned NOAA Sea Grant funded project. This project is funded through 05/31/05. To date the progress of this project has led us to the conclusion that single point injection is the preferred method for injecting ozone into ballast water for the treatment of ANS. Additional results will be useful when we begin the proposed scientific testing phase of this project. The research plan for the proposed project will likely be quite similar to this project; with the obvious small scale/full scale differences. William Cooper's PI time commitment for this project is ½ month per year. A copy of this grant is provided as Exhibit 3.

- Demonstration of Ship-Board Ozone Treatment and Process-Control Strategies for the Control and Mitigation of Aquatic Nuisance Species – This USF&W project is funded through September 30, 2004. This project provided the biological results that prove ozone is effective in eliminating ANS in ballast water through various funded experiments on board the S/T Tonsina. Specifically the following:
    - The concentration of culturable bacteria declined 99.9%.
    - The zooplankton examined were determined to be 71-99% dead or moribund.
    - The concentration of vegetative cells for dinoflagellates and microflagellates declined 91-100%.

  William Cooper's PI time commitment for this project is ½ month per year. A copy of this grant is included as Exhibit 5

- Aquatic Nuisance Species - Control and Mitigation: Ozone Treatment of Ballast Water – This NOAA Sea Grant project is funded through September 30, 2004. When complete, this project will show that ozone is more effective than ballast water transfer and will also determine toxicity levels in discharged ozonated ballast water. William Cooper's PI time commitment for this project is ½ month per year. A copy of this grant is included as Exhibit 4.

Project Objectives

This final series of tests, to be funded by the cooperative research grant, will determine the effectiveness of a new, single point injection technology for injecting ozone into the ballast water. We believe this technology will be more effective in killing the invasive species, because far greater quantities of ozone will be injected and the distribution of ozone will be uniform through the ballast water . It will also be far less expensive to install since only a single 50 foot to 100 foot pipe, and a venturi, will be required to inject the ozone into the ballast water intake pipe. On the S/T Tonsina, nearly 21,000 feet of pipe was required because the ozone was injected into the ship's ballast water tanks. Therefore, our objective will be to prove our theory that injecting ozone into ballast water via a single point is more effective in removing invasive aquatic species that our system onboard the S/T Tonsina.

We also plan to definitively demonstrate that ballast water treated with ozone will not create any environmental hazards when it is discharged from the ship. The injected ozone reverts to oxygen within a few seconds. We believe any toxic levels of bromine, or bromate ion, created by the ozone will either rapidly disintegrate to levels that meet with accepted discharge guidelines or may be easily removed by the introduction of additional off-the-shelf chemicals that are routinely used to remove excess chlorine from chlorinated municipal water supplies.

Methods and Program Design

It is our intent to select a ship, design a single point ozone injection system for this ship, install the system on the ship during an early 2005 out-of-service period, and test the effectiveness of this system in the control of invasive aquatic species. The details of this plan are discussed in our statement of work. A general plan for our scientific protocol is found below.

Goal: To establish the absolute treatment efficiency of the single point ozonation process for organisms at the various trophic levels in ballast water under “normal” ship operations.

Treatment Goal: Would be to achieve established limits, e.g. State of Washington and/or IMO Treaty Goals.

Experimental Considerations:

1. Organisms to be studied – Trophic levels
    a. Bacteria
    b. Phytoplankton
    c. Zooplankton
    d. Caged Organisms

2. Control Studies

    No treatment

3. Time Course
    a. TRO concentrations – two maximum
    b. TRO decomposition with time (C*T)

4. WET Testing
    a. Function of TRO

5. Chemical Characterization
    a. Water Quality Parameters
        i. Baseline data for each experiment
        ii. Have shown extensively that none are altered – necessary to do more?
    b. Bromoform

6. Open Ocean Exchange
    None planned

7. Laboratory Experiments for selected pathogens and indicator organisms
    a. Vibrio cholerae
    b. Escherichia coli
    c. Enterococcus sp.

Sampling

1. Multiple Depths in Treatment Tanks
    a. Flowing water via lines
        i. Bacteria
        ii. Phytoplankton
        iii. Chemistry
    b. Vertical tows
        i. Zooplankton
    c. Niskin Bottles (if necessary)

2. Time
    a. e.g. 0, 2.5, 5.0 7.5 and 10 hours for most parameters
    b. 0, 5.0 and 10.0 for zooplankton

3. Multiple horizontal sampling points

4. Seasonal sampling

5. Sampling/tests at both ports of call
    a. North
    b. South

Analysis

1. Ship Board
    a. Heterotrophic plate counts (if space is available)
    b. Zooplankton (if space is available)
    c. Chemical Characterization

2. Shore Based
    a. Phytoplankton (chlorophyll and flow cytometry)
    b. 3-D Characterization of treated and untreated water

Control and Monitoring

1. The goal will be to incorporate both on-line, real-time measurements and individual sample analysis of the effluent (and the water in the ballast tank) to control the TRO.

2. Monitoring will be conducted by testing TRO similar to the use of disinfection monitoring used in drinking water.

Output and Anticipated Benefits

The ongoing Sea Grant Funded research at the USGS Marrowstone Marine Field Station has indicated that a single point injection system is efficacious and a cost-effective treatment system for a full scale system installation. Our proposed research will thoroughly examine the efficacy of this in line ozonation system on-board our test vessel. The benefits for preventing the introduction of ANS present in ballast water are numerous and well documented. Future introductions of aquatic nuisance species could result in enormous economic and environmental impacts.

III. Statement of Work

A detailed project timeline is provided at Exhibit 2 to this proposal. Each of the major tasks will be discussed further in this section. The timeline was developed with the anticipation of receiving NOAA approval on May 1, 2004. This will mark the official beginning of the project. The project is scheduled to end one year later on April 30, 2005, with our final report being submitted to NOAA on May 31, 2005.

Administrative Tasks

The tasks in this section of the project involving the various planning and proposal building functions that must occur before the project can be funded and actually started in earnest. The majority of these efforts have taken place in February and early March 2004 culminating with the submission of our proposal to NOAA on March 12, 2004. At this point in time we anticipate having selected a test vessel.
The remainder of the Administrative tasks will hinge upon the approval of this proposal by NOAA. Once authorization is received, all subcontracts for design and science work can be released and the actual project can commence.

Administrative tasks that will be on-going during the course of this project include monthly status reports to NOAA as well as submission of the final report to NOAA upon completion of the project. We anticipate the monthly status reports will be one mechanism for requesting funding prior to the funding events we identify in the budget section of this proposal.

Design/Engineering Tasks (May – October 2004)

Obtain Project Vessel data and drawings from Owner

Perform initial review

1. Gather detailed information on subject vessels –

This task has been completed prior to the submission of this proposal. Some preliminary drawings have been received and are ready for our engineering team to act upon in the detail listed below. Information as to the specific routes and dry dock schedules will be gathered as well. The basis for the selection of a project will be as follows.

- Ship size and ballast water capacity
- Flow rate of ballast pumps
- Route and trade schedule
- Compatible shipyard period schedule
- Available space for locating of ozonation equipment
- Willingness of vessel Owner to provide test platform
- Available accommodations for testing team

2. Prepare Conceptual sketches

Sketches will be prepared in order to give our engineering team the necessary information to make preliminary system design calculations. These sketches will form the foundation from which equipment components are chosen.

3. Perform preliminary system design calculations

These design calculations will be the basis behind the selection of the major equipment purchases (ozone and oxygen generator).

4. Perform survey of project vessel

This task will include a trip to the vessel to verify the assumptions made in the conceptual sketches and preliminary design calculations.

5. Update conceptual drawings to reflect survey information

Any changes based on the vessel survey will be made to the conceptual design sketches and calculations.

6. Meet with major vendors as required

Once these meetings occur, orders for long lead items can be placed. We anticipate these items to include the both the oxygen and ozone generators.

Prepare "design level" drawings

1. Prepare "design level" drawings and complete internal review

Design level drawings will show the major components of our system as well as how they integrate into the existing ships systems. These are the drawings necessary to begin the ABS and Coast Guard approvals for shipboard installations.

2. Perform review with project vessel owner, including HAZ/OP review

This review will give the project vessel owner and his hazardous operations team a chance to go over the design level drawings and give their approval to go forward with ABS and Coast Guard approval.

3. Finalize "design level" drawings

Any changes suggested by the vessel owner will be incorporated into the drawings prior to seeking ABS and USCG approval.

4. Prepare "installation plan"

This plan will be an outline of the installation process. An installation schedule will be worked out with the vessel owner at this time.

5. Submit drawings for ABS/USCG approval

Design level drawings will be submitted to ABS and USCG by the end of July, 2004.

6. ABS/USCG Review and approval

We expect to receive ABS approval by the end of September 2004 and USCG approval by the end of October 2004.

Prepare "detail level" drawings

1. Meet with major vendors as required

The purpose of these meetings will be to finalize our long lead equipment orders and make any changes to them as a result of our vessel owner, ABS, and USCG meetings.

2. Prepare "detail level" drawings and installation specification

These will be detailed component, by component drawings and a detailed plans and drawings for the installation of the equipment on board the ship

3. Internal and vessel owner review

We expect a 2 week review process.

4. Finalize detail level drawings and installation specification

After review, we expect this process to take 10 days.

5. Present installation plan to vessel owner and receive vessel owner approval

We expect this to occur by the end of September 2004

6. Provide assistance to vessel owner for Coast Guard STEP program application

We will assist the vessel owner in all aspects of the STEP board application process and approval process if accepted into the program

7. Provide assistance to NOAA for NEPA review, if required

Assistance will be provided to NOAA for any NEPA review, if required

Equipment Assembly/Fabrication (June 21 – November 19, 2004)

1. **Place all orders for both long and short lead items**
2. **Receive parts and equipment and purchase assembly hardware**
3. **Modify equipment container**
4. **Fabricate foundations, brackets, supports, etc.**
5. **Install foundations in equipment container**
6. **Assemble components into container**
7. **Complete piping/wiring/etc.**

SHOP Tests (of full scale unit) (November – December 2004)

These tests will be done to make sure the unit is operating correctly prior to shipping the equipment to the shipyard for installation on the owner vessel.

1. **Dock trials**

   This will be the first set of tests, following a specific protocol, to insure correct operation

2. **System trials**

   This will be the second set of tests, following a specific protocol, to insure correct operation

3. **Acceptance trials**

   This will be the final set of tests performed to insure correct operation.

   a. ***Prepare report and recommendations for shipyard trials***
   b. ***Package equipment for shipment***
   c. ***Ship equipment to installing shipyard***

Equipment Installation (October 2004 – January 31, 2005)

4. **Project vessel owner submits installation drawings and specifications to ship yard for costing**

5. **Assist project vessel owner with shipyard questions**

6. **Select installing shipyard (by owner)**

7. **Begin shipyard installation period**

8. **Begin shipyard tests**

    a. ***Dock trials***
    This will be the first set of tests, following a specific protocol, to insure correct operation

    b. ***System trials***
    This will be the second set of tests, following a specific protocol, to insure correct operation

    c. ***Acceptance trials***
    This will be the final set of tests performed to insure correct operation.

9. **Provide FINAL report and recommendations for FIELD trials**

Scientific Effort

1. **Select and approve members for advisory panel and science testing team (May 2004 – July 2004)**

2. **Development of Testing Protocol (July 2004 – October 11, 2004)**

    a. ***Review and approve protocol internally***

    b. ***Submit for review to NOAA and advisory panel***

    c. ***Present protocol to NOAA and advisory panel***

    d. ***Modify protocol based on recommendations***

    e. ***Submit final protocol***

3. **Field Testing of shipboard unit (01/31/05-04/15/05)**
   These tests will follow the specific protocol that is to be developed by our scientific team. Each test will be followed by data analysis and a written report of the findings.

    a. ***Final Report Preparation*** The report will be written, reviewed, modified and updated after each field test. At the end of all field testing, the a final report will be written to be submitted to NOAA by May 31, 2005

    b. ***Final Report Submission (May 31, 2005)***

IV. Budget

NOAA COOPERATIVE AGREEMENT - OZONE PROJECT				
BUDGET TOTALS BY FUNDING EVENTS				
FUNDING EVENTS	**DATE**	**EFFORT FUNDED**	**FUNDS REQUESTED**	
INITIAL PROJECT ACCEPTANCE	5/3/2004	DESIGN EFFORT	$ 215,026	
COMPLETION OF CONCEPTUAL DRAWINGS	6/11/2004	LONG LEAD EQUIPMENT	$ 450,578	
AND MAJOR EQUIPMENT SELECTION		SCIENCE TEAM FOR PROTOCAL DEVELOPMENT		
EQUIPMENT FABRICATION AND ASSEMBLY	9/10/2004	BALANCE OF EQUIPMENT	$ 484,897	
		ASSEMBLY AND FABRICATION		
SHOP TESTING OF OZONE SYSTEM	10/8/2004	EQUIPMENT SHOP TESTING	$ 75,652	
INSTALLATION OF EQUIPMENT	12/17/2004	INSTALLATION/SHIPBOARD TESTING	$ 261,926	
SCIENCE EFFORT	1/14/2005	BALANCE OF SCIENCE TEAM	$ 211,921	
		TOTAL FUNDING	$ 1,700,000	

The above chart shows the requested budget by major funding event. A narrative of the funding events is provided below. The complete budget in the NOAA format as well as a justification narrative is provided as Exhibit 1.

- **Initial Project Acceptance (05/03/04)** – This funding will cover the design and engineering tasks described above in our statement of work. These are tasks that must be accomplished prior to our development of a detailed Bill of Materials and final equipment selection. The trigger event for this funding will be the initial acceptance of our proposal and the initial authorization to move forward on this project.
- **Completion of Completion of Conceptual Drawings and Major Equipment Selection (06/11/04)** – Once the drawings are complete and have been approved by the vessel owner, initial orders for long term lead items can be placed. After several meetings with our major equipment suppliers, we anticipate the ozone generator and oxygen generators to be the both the most expensive and longest lead time items. We estimate about 40% of the equipment budget would be required at this time for initial deposits with the major equipment vendors. This would also mark the time when we can begin the development of the detailed testing protocol as we would know the general equipment layout and would have identified the ship and the geographic area in which it operates. Various members of the yet to be developed scientific testing team will participate in this effort and funding will be needed to cover their efforts at this time. The trigger event for this funding will be the completion of the conceptual drawings.

- **Equipment Fabrication and Assembly (09/10/04)** - Equipment will be received during the month of September and fabrication and assembly can begin. At this time, final payments to equipment providers will need to be funded in addition to funding to cover the fabrication and assembly effort. The trigger event for this funding will be the issuance of our August 2004 monthly status report. This report will indicate the arrival dates and final payment due dates for major equipment purchases.
- **Shop Testing of Ozone System (10/08/04)** - After completion of fabrication and assembly, the next step to be funded will be the shop testing of the ozone system prior to delivery to the ship. The trigger event for this funding event will be the September 2004 monthly status report. This report will indicate that fabrication and assembly is complete and that shop testing can begin.
- **Installation/Testing of equipment onto ship (12/17/04)** - Once the shop testing phase is complete; the equipment will be shipped to dockside to be loaded onto the vessel. During the months of October, November and December, this testing will be completed and a shipyard will be selected. Funding will be required at this time to cover the shipyard installation and testing of our equipment on our test vessel. The trigger event for this funding will be the selection of a shipyard by the vessel owner.
- **Science Effort (01/14/05)** - After the ship is outfitted and the equipment is tested in the shipyard, we expect to begin field trials of our equipment immediately. At this time the science team will be activated to initiate our testing protocol and funding will be required to fund their efforts from January 2005 through project completion. Due to the fact the exact protocol is not known nor the exact timing of this effort known, this funding date may change as we proceed through the various stages of this cooperative agreement. The trigger event for this funding request is the completion of the shipboard installation and testing.

NOAA – Nutech O3 Cooperative Agreement

Budget Justifications

Personnel and Fringe - $114,697

W.J. Cooper, 5 months is requested for Dr. Cooper. As lead scientist on the project he will be responsible for coordinating all of the scientific studies and leading the effort on writing up the results in a timely manner. He will also oversee the technical support from UNCW and take the lead in the photochemical studies of TRO dissipation in the environment. He will also actively be involved in most of the field studies and over see the research assistants that are to be used in these studies. $42,220

Research Assistant. This will be a person with a minimum of a M.S. degree. They will be responsible for coordinating the on-site studies at the ship, at the port of departure and arrival. They will also conduct the day-to-day studies on photochemical dissipation of the TRO under sunlight conditions. $25,000

The normal University fringe of 26 % is included. $17,477.20 calculated on a base of $67,220

Program Management – This will cover the Nutech O3 project management and administration functions. Not only will this cover Michael Jennings, principal investigator-admin., but it will also cover any legal assistance and the participation of Nutech O3's upper management in any project decision making and guidance. $30,000

Travel - $23,000

This travel budget includes all travel of the scientific team and principal investigators. Travel will be from individual home cities to the test site locations and also will include any trips necessary to visit with equipment vendors, ABS/Coast Guard, or to present status reports to NOAA.

Permanent Equipment - $747,970

This includes the ozone generator and all ancillary equipment. The equipment will be provided by Nutech O3. The exact bill of materials cannot be determined until the design and engineering phases of the project are complete. However, we anticipate the major components to include the following.

- Ozone Generator – capacity to be determined by ballast pump flow
- Air Compressor – matched to ozone generator flow rates
- Oxygen Generator – matched to ozone production
- Ozone Destruct Unit – for testing purposes
- Venturi Injector Assembly
- Venturi circulating system module
- Fire Suppression System

- Shipping

Assembly/Fabrication/Installation/Testing - $425,000

These tasks are discussed in detail in our project timeline. They include preassembly of the shipboard system components, fabrication of any necessary bracketing, housing, and mounting devices, and both shipboard and pre-installation equipment testing. All shipyard work is a component of this line item as well.

- Assembly and Fabrication $125,000 (8.5 man months)
- Shipyard Installation $250,000 (17 man months)
- Testing (pre and post install) $50,000 (3.5 man months)

Contractual Services - $345,000

To include but not be limited to *Bacteria, Phytoplankton, Zooplankton analysis; caged organism studies, and WET Testing* - These estimates are based upon our existing projects in ballast water. University of Washington is likely to take the lead in studies on bacteria, phytoplankton and zooplankton. Parametrix will likely conduct all of the WET testing and be involved in additional toxicity tests for organism not yet studied. However, at the current time, no specific firms or individuals are identified pending selection of the ship/location to be used and the development of our testing protocol. $130,000

Result Analysis and Review - The Iowa State University is included in the scientific team with J (Hans) van Leeuwen; Professor of Environmental Engineering participating. One month of his time is requested. $15,000

Engineering and Design - This work will be performed by NETSCO and will include those tasks detailed in the project timeline. These tasks are necessary in order to select a ship, properly size all equipment, and to obtain vessel owner, ABS, USCG, and HAZ-OP approvals prior to installation. $200,000 (13 man months)

Other - $4,000

These funds are requested for student assistants for the ship-board experiments. These students will be obtained locally whenever possible to minimize costs.

Indirect Charges - $40,332

Represents the UNCW rate of 60% on the UNCW base of $67,220